Ocean Data Telemetry Microsat Link (ODTML)

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LONG-TERM GOALS

The long term goal of this program is to have a world-wide real-time ocean monitoring system, which will service all ocean data platforms.

OBJECTIVES

This Phase II work will result in a robust, cost-effective two-way (space-to-ground and ground-to-space) satellite system with significant increases in the amount of data that can be collected from autonomous platforms. Of primary importance is a two-way delay-tolerant messaging capability providing Internet-like services on a global basis. The ODTML architecture should allow evolution and expansion for future sensors, and it should decouple platform (buoy) upgrades from future space segment system upgrades. Thus, new technology should be able to be introduced seamlessly into either the sensor grid or the satellite system. This work is the first step toward the development of a cost-effective, space-qualified Spacecraft Communications Payload (SCP) to meet the DoD (and civil sector) needs for a real-time Integrated Ocean Observing System, and general purpose data exfiltration/infiltration system. The U.S. Navy will be the direct beneficiary of the system, as it will enhance the Navy's ability to gather sensor information on a global and near real-time basis, by interrogating and tasking ocean observing platforms. Such capability has applications in the area of anti-submarine warfare, surveillance, and other ocean-monitoring activities.

APPROACH

Our approach is to design, develop, demonstrate, and test an engineering development unit of the ODTML system (Figure 1). The ODTML network system, consists of the following elements: a micro-satellite SCP (serving as a “router in the sky”), ocean observing platforms (e.g., free-floating buoys), ground stations acting as Radio Frequency (RF) gateways, and the Internet as the communication conduit between the users and the ocean monitoring platforms. Applying the concept of IP addressing of sensor nodes and Internet-based “instant messaging,” we will create a network out of the

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traditionally inefficient ocean monitoring platforms and the associated communications relay system. The users will be able to interrogate and task a number of ocean monitoring platforms, gather geographically distinct measurements nearly simultaneously for an extended period of time, and thereby acquire an improved awareness of the target environment. Sensor network technology allows near real-time exchange, which includes node-to-node type (when nodes are within line-of-sight of each other) and node-to-relay (when nodes are beyond line of sight from each other). The stand-off distances can be in tens to hundreds of kilometers. Data transmission rates can range from 1200 to 9600 bps.

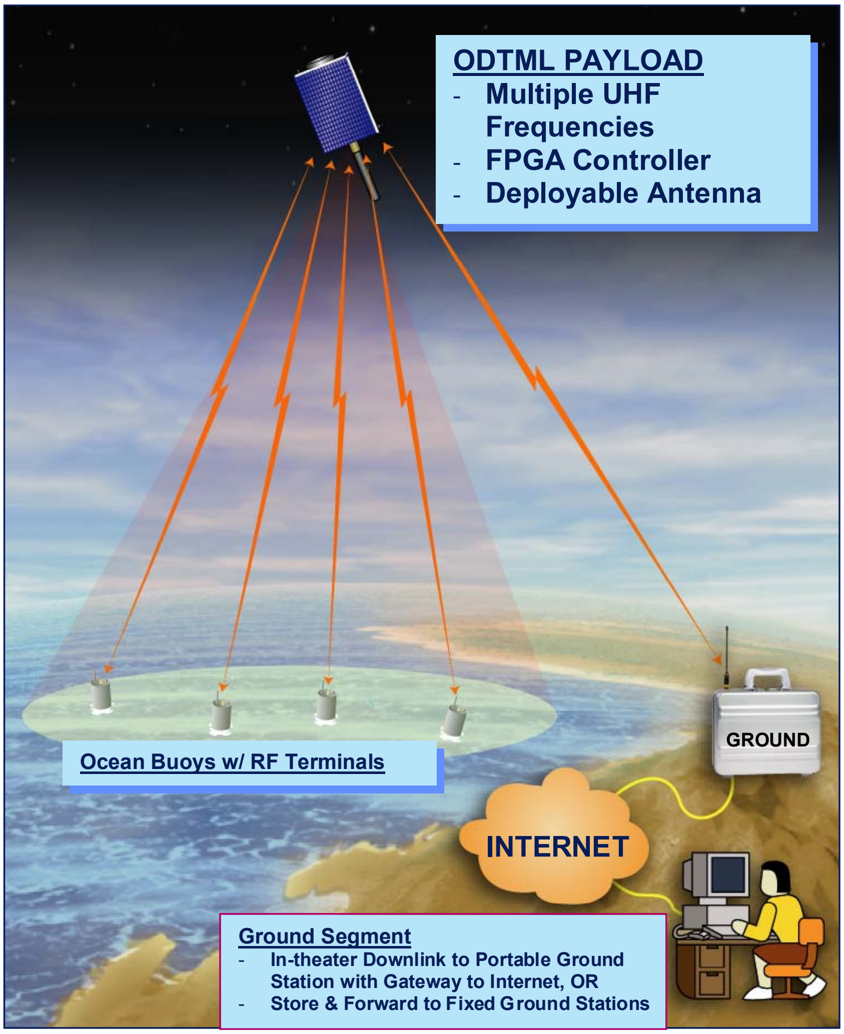

Figure 1. Ocean Data Telemetry Microsat Link System Architecture (ODTML)
[ODTML consists of RF terminals on ocean buoys, a payload on a microsatellite, and a portable ground station connected to the internet for tasking and data dissemination]

Praxis proposes to develop, design and build a low cost, low power, space qualified, two-way communications payload for the microsatellites. This payload will be a protoflight version of the Space communications payload (SCP) concept originally envisioned in ONR SBIR, N02-062, Ocean Data Telemetry MicroSat Link, and will use a Commercial Off-The-Shelf (COTS) RF transceiver, furnished by SpaceQuest, Inc., and an antenna. This payload, to be built by Praxis in conjunction with Silver

Engineering, Inc., will provide data exfiltration/infiltration capabilities via the Internet for ocean buoys and other low data rate sensors.

The proposed payload architecture will allow evolution and expansion for future sensors, while maintaining backward compatibility with all existing data systems. It will decouple platform (buoy) payload upgrades from future space segment system upgrades. Thus, new technology will be able to be introduced seamlessly into either the sensor grid or the satellite system. Because of the modularity, small size, low power, and ease of installation, the SCP will be capable of integration on many different space platforms. It is envisioned that this will enable deployment of additional ODTML payloads, either as a mix of stand-alone microsatellites or as secondary payloads aboard host space vehicles, increasing the number of SCPs in space. This will move the U.S. Navy closer to the goal of persistent monitoring by allowing a gradual expansion of the overall system as launch opportunities arise. By having available a low cost payload that can be quickly and cheaply integrated onto a space flight of opportunity, we will be evolving toward a constellation of payloads providing near-persistent surveillance.

WORK COMPLETED

(1) Praxis refined and finalized the system architecture for ODTML and documented the architecture in a Systems Description Document (SDD).

(2) Completed concept design of the SCP and presented it at the Preliminary Design Review on 3 Feb 06.

(3) Developed the payload interface requirements for the TacSat-3 satellite and compiled them into an ICD.

(4) Performed flight-quality thermal and structural design analysis.

(5) Specified, designed, built, and procured the RF modems and the transceiver to meet the ODTML RF communications requirements.

(6) Added memory management to the 8051 microcontroller (which is IP hosted on the FPGA) such that a large number of messages can be stored in the SCP.

(7) Expanded buoy addressing and messaging protocol to add station keeping command and status traffic for the SCP.

(8) Integrated and tested the upgraded breadboard SCP and RF modems/transceivers with the existing Phase I communications protocol and the upgraded protocol.

RESULTS

Praxis completed the base period SBIR phase II effort in FY06. Under the SBIR Phase II effort, Praxis was required to design, develop, demonstrate, and test an engineering development unit of the ODTML system. All of the tasks were completed as described in the ODTML Phase II Base Final Report.

Based on the successful completion of all Base period tasks, we have recommended that we proceed with all three tasks of the Phase II Option effort which would complete the design and build of a SCP flight unit, and prepare it for a field demonstration on the TacSat-3 spacecraft.

IMPACT/APPLICATIONS

This work is the first step toward the deployment of a constellation of cost effective, space qualified SCPs to meet the DoD (and civil sector) needs for a real-time Integrated Ocean Observing System. The U.S. Navy will be the direct beneficiary of the system, as it will enhance the Navy's ability to gather sensor information on a global and near real-time basis by interrogating and tasking ocean observing platforms. Such capability has applications in the area of ASW, surveillance, and other ocean-monitoring activities. An ancillary benefit would be the ability to also monitor other data sensors, such as unattended ground sensors and Low Probability of Intercept (LPI) communication devices. In fact, once a system is in place, it could be used for data exfiltration from a host of different data terminals.

The ability to provide near real-time situational awareness is essential for the next generation ocean observing system because the response time to an occurring event, military or scientific, is increasingly tied to operational effectiveness. The ability to query or interrogate a sensor that has detected an event is important because users often desire confirmation or more frequent observation of the event. Current systems do not meet these needs because they are based on dated technologies.

A major achievement of this program will be the increased intelligence value realized by being able to network a group of individual sensors into a grid of smart, cooperative nodes. With on board processing, smart sensor nodes will evaluate gathered data and make knowledge-based decisions on whether to notify other sensors or query them on their information. In other words, they will become a team, sharing data and helping each other to know either what has happened or what to expect. Data fusion, data sharing, and data queuing are all new capabilities that will be introduced by this concept of networking smart sensors. This will greatly enhance the intelligence value of the sensor grid over having individual sensors unable to communicate.

TRANSITIONS

None.

RELATED PROJECTS

Spacecraft Communications Payload (SCP) for ONR Swampworks Office. The SCP program will build a payload to fly on the TacSat-3 spacecraft. The SCP payload will be the router in the sky for the ODTML system of data buoys. It will be the communications hub for the entire system envisioned in the ODTML SBIR. This proposal will enable an operational evaluation of the present payloads (Aprizesat payloads), and the improvement of any shortcomings identified in this demonstration, thus resulting in an enhanced SCP.

Smart Sensor Node (SSN) In House (Praxis) R&D Effort. To evolve to this "smart" sensor goal, Praxis undertook an in-house effort to design a small, low cost RF terminal with a CPU and a DSP to increase the processing capability of terminals to allow on-board data fusion. These SSNs are now more than just dumb data terminals, and being able to process and share data allows them to react to detected data and queue other buoys based on the detected event, greatly enhancing their overall effectiveness.

Integrated Sonobuoy Advanced Networking (ISAN), NAVAIR SBIR N03-189. This SBIR's objective was to develop a system design and feasibility concept for an integrated ocean data collection system. Central to this design was the SCP acting as a "router in the sky" communicating with smart sensor nodes. Praxis defined requirements for a SCP that could fly on either an aircraft or a spacecraft.

TacSat Program. The Office of Force Transformation (OFT) started the TacSat program in 2003, and has passed its program management on to AFRL. This program is looking for fast turnaround, low cost payloads to fly to demonstrate that space doesn't have to "cost too much and take too long." NRL built TacSat-1 and AFRL is building TacSat-2 and TacSat-3. TacSat-2 is nearing completion and TacSat-3 is in the planning stage with a projected launch date of 17 October 2007. Our schedule for the SCP will allow us to meet that date.

OFT Standard Bus Program. OFT has funded AFRL and NRL to come up with a generic bus design to be used for TacSat-4 and beyond. The SCP is likely to be manifested on future TacSats because of its small size and low cost.

DoD Space Test Program. This is a DoD program that funds I&T costs for payloads to fly in space. Each year a competition is held and payloads are evaluated, and an attempt is made to match payloads with available space rides. ODTML was ranked in the 2004 SERB, and the SCP is built and manifested on TacSat-3. STP will furnish the funds to integrate it onto the TacSat-3 spacecraft.